Claims

1. A peak to average power ratio reducer (PAPR) for a multi-carrier modulation (MCM) communication system comprising:

a MCM transmitter comprising:

a probability distribution transformer having an input for receiving an MCM signal for transmission, the MCM signal comprising a plurality of data packets, wherein the plurality of data packets represent a plurality of amplitude values, wherein the plurality of amplitude values is characterized by a substantially Gaussian probability density function, the probability distribution transformer for transforming the plurality of amplitude values to a plurality of transformed amplitude values in accordance with a probability distribution transform, wherein the plurality of transformed amplitude values is characterized by a substantially uniform probability density function, and the probability distribution transformer having an output for providing a transformed MCM signal comprising a plurality of transformed data packets, wherein the plurality of transformed data packets represent at least some of the plurality of transformed amplitude values; and

a MCM receiver comprising:

a probability distribution inverter having an input for receiving a corresponding transformed MCM signal, the probability distribution inverter for transforming the at least some of the plurality of transformed amplitude values to a plurality of inverted amplitude values in accordance with an inverse probability distribution transform, wherein the plurality of inverted amplitude values is characterized by a substantially Gaussian probability density function, and the probability distribution inverter having an output for providing a recovered MCM signal comprising a plurality of inverted data packets, wherein the plurality of inverted data packets represent at least some of the plurality of inverted amplitude values.

2. A PAPR reducer in accordance with claim 1, wherein the probability distribution transformer comprises a plurality of linear transformers for transforming the plurality of amplitude values to the plurality of transformed amplitude values.

3. A PAPR reducer in accordance with claim 2, wherein the plurality of linear transformers comprises at least one linear transformer for transforming a first predetermined band of amplitude values in accordance with the following equation:

$$y = (a/\sigma)\, x$$

where x is one of the plurality of amplitude values;

y is a corresponding one of the plurality of transformed amplitude values;

a is a predetermined constant; and

σ is standard deviation of the plurality of amplitude values.

4. A PAPR reducer in accordance with claim 3, wherein the first predetermined band of amplitude values comprises $|x| \leq \sigma$.

5. A PAPR reducer in accordance with claim 2, wherein the plurality of linear transformers comprise at least one predetermined pair of linear transformers for transforming a corresponding pair of predetermined bands of amplitude values.

6. A PAPR reducer in accordance with claim 5, wherein the at least one predetermined pair of linear transformers and the corresponding pair of predetermined bands of amplitude values comprise:

$$y = (b/\sigma)x + c \quad \text{when } \sigma < x \leq 2\sigma\text{; and}$$

$$y = (b/\sigma)x - c \quad \text{when } -2\sigma \leq x < -\sigma\text{;}$$

where x is one of the plurality of amplitude values;

y is a corresponding one of the plurality of transformed amplitude values;

b and c are predetermined constants; and

σ is standard deviation of the plurality of amplitude values.

7. A PAPR reducer in accordance with claim 5, wherein the at least one predetermined pair of linear transformers and the corresponding pair of predetermined bands of amplitude values comprise:

$$y = (d/\sigma)x + e \quad \text{when } 2\sigma < x \leq 6\sigma\text{; and}$$

$$y = (d/\sigma)x - e \quad \text{when } -6\sigma \leq x < -2\sigma\text{;}$$

where x is one of the plurality of amplitude values;

y is a corresponding one of the plurality of transformed amplitude values;

d and e are predetermined constants; and

σ is standard deviation of the plurality of amplitude values.

8. A PAPR reducer in accordance with claim 5, wherein the at least one predetermined pair of linear transformers and the corresponding pair of predetermined bands of amplitude values comprise:

$$y = f \qquad \text{when } x > 6\sigma\text{; and}$$

$$y = -f \qquad \text{when } x < -6\sigma\text{;}$$

where x is one of the plurality of amplitude values;
y is a corresponding one of the plurality of transformed amplitude values;
f is a predetermined constant; and
σ is standard deviation of the plurality of amplitude values.

9. A PAPR reducer in accordance with claim 1, wherein the probability distribution inverter comprises a plurality of linear transformers for transforming the plurality of transformed amplitude values to the plurality of inverted amplitude values.

10. A PAPR reducer in accordance with claim 9, wherein the plurality of linear transformers comprise at least one linear transformer for a first predetermined band of transformed amplitude values in accordance with the following equation:

$$s = (g\sigma)y$$

where y is one of the plurality of transformed amplitude values;
s is a corresponding one of the plurality of inverted amplitude values;
g is a predetermined constant; and
σ is standard deviation of the plurality of transformed amplitude values.

11. A PAPR reducer in accordance with claim 10, wherein the first predetermined band of transformed amplitude values comprises $|y| \leq 0.4$.

12. A PAPR reducer in accordance with claim 9, wherein the plurality of linear transformers comprises at least one predetermined pair of linear transformers for a corresponding pair of predetermined bands of transformed amplitude values.

13. A PAPR reducer in accordance with claim 12, wherein the at least one predetermined pair of linear transformers and the corresponding pair of predetermined bands of transformed amplitude values comprise:

$$s = (\sigma/h)(y - i) \qquad \text{when } 0.4 < y \leq 0.55\text{; and}$$

$$s = (\sigma/h)(y + i) \qquad \text{when } -0.55 \leq y < -0.4\text{;}$$

where y is one of the plurality of transformed amplitude values;
s is a corresponding one of the plurality of inverted amplitude values;
h and i are predetermined constants; and

σ is standard deviation of the plurality of transformed amplitude values.

14. A PAPR reducer in accordance with claim 12, wherein the at least one predetermined pair of linear transformers and the corresponding pair of predetermined bands of transformed amplitude values comprise:

$$s = 10\sigma(y - j) \quad \text{when } 0.55 < y \leq 0.95\text{; and}$$

$$s = 10\sigma(y + j) \quad \text{when } -0.95 \leq y < -0.55\text{;}$$

where y is one of the plurality of transformed amplitude values;
s is a corresponding one of the plurality of inverted amplitude values;
j is a predetermined constant; and
σ is standard deviation of the plurality of transformed amplitude values.

15. A PAPR reducer in accordance with claim 12, wherein the at least one predetermined pair of linear transformers and the corresponding pair of predetermined bans of transformed amplitude values comprise:

$$s = 6\sigma \quad \text{when } y > 0.95\text{; and}$$

$$s = -6\sigma \quad \text{when } y < -0.95\text{;}$$

where y is one of the plurality of transformed amplitude values;
s is a corresponding one of the plurality of inverted amplitude values; and
σ is standard deviation of the plurality of transformed amplitude values.

16. A PAPR reducer in accordance with claim 2, wherein the inverse probability distribution transformer comprises a plurality of inverse linear transformers, where in the plurality of inverse linear transformers are the inverse of the plurality of linear transformers, the plurality of inverse linear transformers for transforming at least some of the plurality of transformed amplitude values to at least some of the plurality of amplitude values.

17. A multi-carrier modulation (MCM) transmitter comprising:

a probability distribution transformer having an input for receiving an MCM signal for transmission, the MCM signal comprising a plurality of data packets, wherein the plurality of data packets represent a plurality of amplitude values, wherein the plurality of amplitude values is characterized by a substantially Gaussian probability density function, the probability distribution transformer for transforming the plurality of amplitude values to a plurality of transformed amplitude values in accordance with a probability distribution

transform, wherein the plurality of transformed amplitude values is characterized by a substantially uniform probability density function, and the probability distribution transformer having an output for providing a transformed MCM signal comprising a plurality of transformed data packets, wherein the plurality of transformed data packets represent at least some of the plurality of transformed amplitude values.

18. A PAPR reducer in accordance with claim 17, wherein the probability distribution transformer comprises a plurality of linear transformers for transforming the plurality of amplitude values to the plurality of transformed amplitude values.

19. A PAPR reducer in accordance with claim 18, wherein the plurality of linear transformers comprise at least one linear transformer for a first predetermined band of amplitude values in accordance with the following equation:

$$y = (a/\sigma)\, x$$

where x is one of the plurality of amplitude values;
y is a corresponding one of the plurality of transformed amplitude values;
a is a predetermined constant; and
σ is standard deviation of the plurality of amplitude values.

20. A PAPR reducer in accordance with claim 19, wherein the first predetermined band of amplitude values comprises $|x| \leq \sigma$.

21. A PAPR reducer in accordance with claim 18, wherein the plurality of linear transformers comprise at least one predetermined pair of linear transformers for a corresponding pair of predetermined bands of amplitude values.

22. A PAPR reducer in accordance with claim 21, wherein the at least one predetermined pair of linear transformers and the corresponding pair of predetermined bands of amplitude values comprise:

$$y = (b/\sigma)x + c \quad \text{when } \sigma < x \leq 2\sigma; \text{ and}$$

$$y = (b/\sigma)x - c \quad \text{when } -2\sigma \leq x < -\sigma;$$

where x is one of the plurality of amplitude values;
y is a corresponding one of the plurality of transformed amplitude values;
b and c are predetermined constants; and
σ is standard deviation of the plurality of amplitude values.

23. A PAPR reducer in accordance with claim 21, wherein the at least one predetermined pair of linear transformers and the corresponding pair of predetermined bands of amplitude values comprise:

$$y = (d/\sigma)x + e \quad \text{when } 2\sigma < x \leq 6\sigma\text{; and}$$

$$y = (d/\sigma)x - e \quad \text{when } -6\sigma \leq x < -2\sigma\text{;}$$

where x is one of the plurality of amplitude values;

y is a corresponding one of the plurality of transformed amplitude values;

d and e are predetermined constants; and

σ is standard deviation of the plurality of amplitude values.

24. A PAPR reducer in accordance with claim 21, wherein the at least one predetermined pair of linear transformers and the corresponding pair of predetermined bands of amplitude values comprise:

$$y = f \quad \text{when } x > 6\sigma\text{; and}$$

$$y = -f \quad \text{when } x < -6\sigma\text{;}$$

where x is one of the plurality of amplitude values;

y is a corresponding one of the plurality of transformed amplitude values;

f is a predetermined constant; and

σ is standard deviation of the plurality of amplitude values.

25. A multi-carrier modulation (MCM) receiver comprising:

a probability distribution inverter having an input for receiving a transformed MCM signal, wherein the transformed MCM signal comprises a plurality of transformed data packets, wherein the plurality of data packets represent transformed amplitude values, and wherein the plurality of transformed amplitude values is characterized by a substantially uniform probability density function, the probability distribution inverter for transforming at least some of the plurality of transformed amplitude values to a plurality of inverted amplitude values in accordance with an inverse probability distribution transform, wherein the plurality of inverted amplitude values is characterized by a substantially Gaussian probability density function, and the probability distribution inverter having an output for providing a recovered MCM signal comprising a plurality of inverted data packets, wherein the plurality of inverted data packets represent at least some of the plurality of inverted amplitude values.

26. A PAPR reducer in accordance with claim 25, wherein the probability distribution inverter comprises a plurality of linear transformers for transforming the plurality of transformed amplitude values to the plurality of inverted amplitude values.

27. A PAPR reducer in accordance with claim 26, wherein the plurality of linear transformers comprise at least one linear transformer for a first predetermined band of transformed amplitude values in accordance with the following equation:

$$s = (g\sigma)y$$

where y is one of the plurality of transformed amplitude values;
s is a corresponding one of the plurality of inverted amplitude values;
g is a predetermined constant; and
σ is standard deviation of the plurality of transformed amplitude values.

28. A PAPR reducer in accordance with claim 27, wherein the first predetermined band of transformed amplitude values comprises $|y| \leq 0.4$.

29. A PAPR reducer in accordance with claim 26, wherein the plurality of linear transformers comprises at least one predetermined pair of linear transformers for a corresponding pair of predetermined bands of transformed amplitude values.

30. A PAPR reducer in accordance with claim 29, wherein the at least one predetermined pair of linear transformers and the corresponding pair of predetermined bans of transformed amplitude values comprise:

$$s = (\sigma/h)(y - i) \quad \text{when } 0.4 < y \leq 0.55\text{; and}$$

$$s = (\sigma/h)(y + i) \quad \text{when } -0.55 \leq y < -0.4\text{;}$$

where y is one of the plurality of transformed amplitude values;
s is a corresponding one of the plurality of inverted amplitude values;
h and i are predetermined constants; and
σ is standard deviation of the plurality of transformed amplitude values.

31. A PAPR reducer in accordance with claim 29, wherein the at least one predetermined pair of linear transformers and the corresponding pair of predetermined bands of transformed amplitude values comprise:

$$s = 10\sigma(y - j) \quad \text{when } 0.55 < y \leq 0.95\text{; and}$$

$$s = 10\sigma(y + j) \quad \text{when } -0.95 \leq y < -0.55\text{;}$$

where y is one of the plurality of transformed amplitude values;
s is a corresponding one of the plurality of inverted amplitude values;
j is a predetermined constant; and
σ is standard deviation of the plurality of transformed amplitude values.

32. A PAPR reducer in accordance with claim 29, wherein the at least one predetermined pair of linear transformers and the corresponding pair of predetermined bands of transformed amplitude values comprise:

$$s = 6\sigma \quad \text{when } y > 0.95\text{; and}$$

$$s = -6\sigma \quad \text{when } y < -0.95\text{;}$$

where y is one of the plurality of transformed amplitude values;
s is a corresponding one of the plurality of inverted amplitude values; and
σ is standard deviation of the plurality of transformed amplitude values.

33. A PAPR reducer in accordance with claim 25, wherein the probability distribution inverter comprises a plurality of inverse linear transformers, where in the plurality of inverse linear transformers are the inverse of the plurality of linear transformers, the plurality of inverse linear transformers for transforming at least some of the plurality of transformed amplitude values to at least some of the plurality of amplitude values.

34. A method for peak to average power ratio reduction in a multi-carrier modulation (MCM) communication system comprising:

a) receiving a MCM signal for transmission, wherein the MCM signal comprises a plurality of data packets, wherein the plurality of data packets represent a plurality of amplitude values, and wherein the plurality of amplitude values is characterized by a substantially Gaussian probability density function;

b) transforming the plurality of amplitude values to a plurality of transformed amplitude values in accordance with a probability distribution transform, wherein the plurality of transformed amplitude values is characterized by a substantially uniform probability density function;

c) providing a transformed signal, wherein the transformed signal comprises a plurality of transformed data packets, wherein the plurality of transformed data packets represent at least some of the plurality of transformed amplitude values;

d) transmitting the transformed signal on a communication channel of the communication system;

e) receiving the transformed signal on the communication channel;

f) transforming the at least some of the plurality of transformed amplitude values to a plurality of inverted amplitude values in accordance with an inverse probability distribution transform, wherein the plurality of inverted amplitude values is characterized by a substantially Gaussian distribution; and

g) providing an inverted signal, wherein the inverted signal comprises a plurality of inverted data packets, wherein the plurality of inverted data packets represent some of the plurality of inverted amplitude values.

35. A method in accordance with claim 34, wherein step (b) comprises the step of applying a plurality of linear transforms.

36. A method in accordance with claim 35, wherein step (f) comprises the step of applying a plurality inverse linear transforms, wherein the plurality of inverse linear transforms are the inverse of the plurality of linear transforms.

37. An equalizer in a mutli-channel modulation (MCM) communication system, wherein a signal transmitted on a communication channel of the communication system includes a cyclic prefix, and wherein the communication channel has a plurality of transmission characteristics, the equalizer comprising:

a Fourier transform module having an input for receiving a signal corresponding to the transmitted signal, wherein the received signal is shaped by at least one of the plurality of transmission characteristics, the Fourier transform module for transforming the received signal to produce a transformed signal, and the Fourier transform module having an output for providing the transformed signal;

a compensator having an input for receiving the transformed signal, the compensator having a plurality of variable transmission parameters for compensating the transformed signal for the shaping by the at least one of the plurality of transmission characteristics to produce a compensated signal, and the compensator having an output for providing the compensated signal; and

an inverse Fourier transform module having an input for receiving the compensated signal, the inverse Fourier transform module for transforming the compensated signal to produce an equalized receive signal, and the inverse Fourier transform module having an output for providing the equalized receive signal.

38. An equalizer in accordance with claim 37 wherein :

the Fourier transform module comprises a fast Fourier transform module; and

the inverse Fourier transform module comprises an inverse fast Fourier transform module.

39. An equalizer in accordance with claim 37 wherein the plurality of transmission characteristics comprises a plurality of channel gains of the communication channel, and wherein the plurality of variable transmission parameters comprises a plurality of variable transmission gains.